Performance and Results from the Globe at Night – Sky Brightness Monitoring Network

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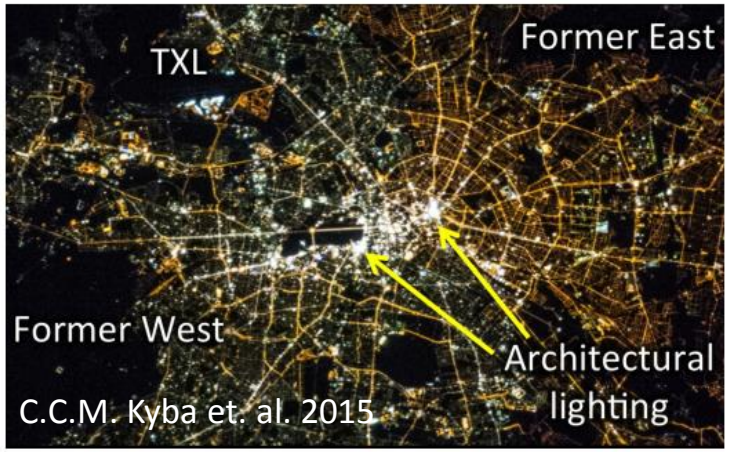
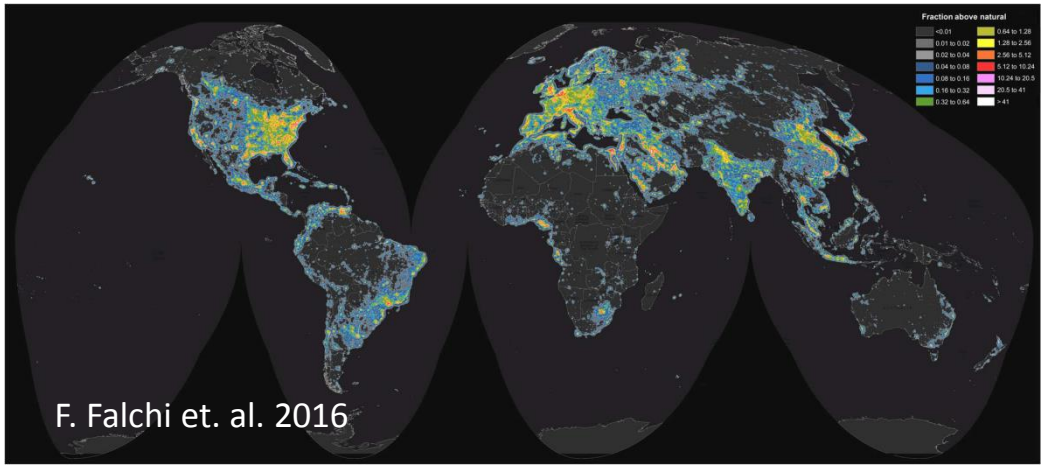
Challenge

To measure the extent of light pollution over large area

1. Measuring Light Up ↑

- **Remote sensing** (DMSP-OLS, VIIRS-DNB, ISS, etc)
  - Upwelling light emitted directly from the light sources and light reflected off the Earth's surface.
  - Challenging calibration issues but can be overcome
  - Large spatial coverage (city → regional → global)
  - Low temporal sampling (each location normally has one chance of overpass within an evening; DMSP: 19:30, VIIRS: 01:30)





2. Measuring skyglow ↑↓

- **Limiting magnitude** (e.g. Globe at Night, since 2006)
  - Citizen science project to report conditions of the night sky
  - Large geographical (115 countries) & temporal coverages with low cost
  - Uncertain data quality within the data set ($\pm$1.2 mag, due to various observing experience & mistakes made during data reporting, Kyba 2013)

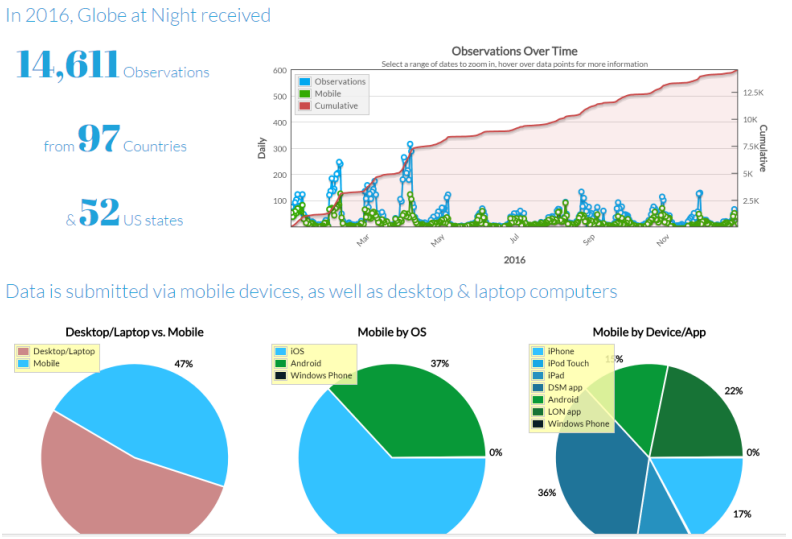


Image credit: Globe at Night

2. Measuring skyglow ↑↓

- **Measuring Night Sky Brightness (NSB)**
  - Through mobile phone apps or specialized light sensing meters
  - Mobile phone citizen science (e.g. Dark Sky Meter): good geographical but unsteady temporal coverage
  - Dedicated measuring devices: for SQM, limited temporal and geographical coverage
  - With ethernet or data-logger versions of SQM, we can set high sampling rate also good temporal coverage
  - **Temporal coverage provides a direct linkage with the pattern of light usage.**

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Endorsed by the IAU Executive Committee Working Group for the **International Year of Light 2015** as a major Cosmic Light program
- Co-organizers:
  - Office of Astronomy Outreach, International Astronomy Union (IAU)
  - National Astronomical Observatory of Japan
  - The University of Hong Kong
  - The Globe at Night project

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Project aims:
  - **Standardized** night sky measurement method for worldwide research on light pollution
  - Highlight the negative **environmental impacts** of abusive artificial lighting for the general public and **policy makers**
  - Sustain light pollution **public education** and promote **public engagement** by live worldwide night sky brightness data and night sky measuring programs

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Methodology and highlights:
  - Zenith night sky brightness observation
  - Standardized observing method:
    - SQM-LE
      - Reasonable cost and sturdy
    - Standard Unihedron housing
      - reduce inconsistency in optical window attenuation
    - 30 seconds sampling interval
    - Standardized calibration scheme

Image credit: Taipei Astronomical Museum

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

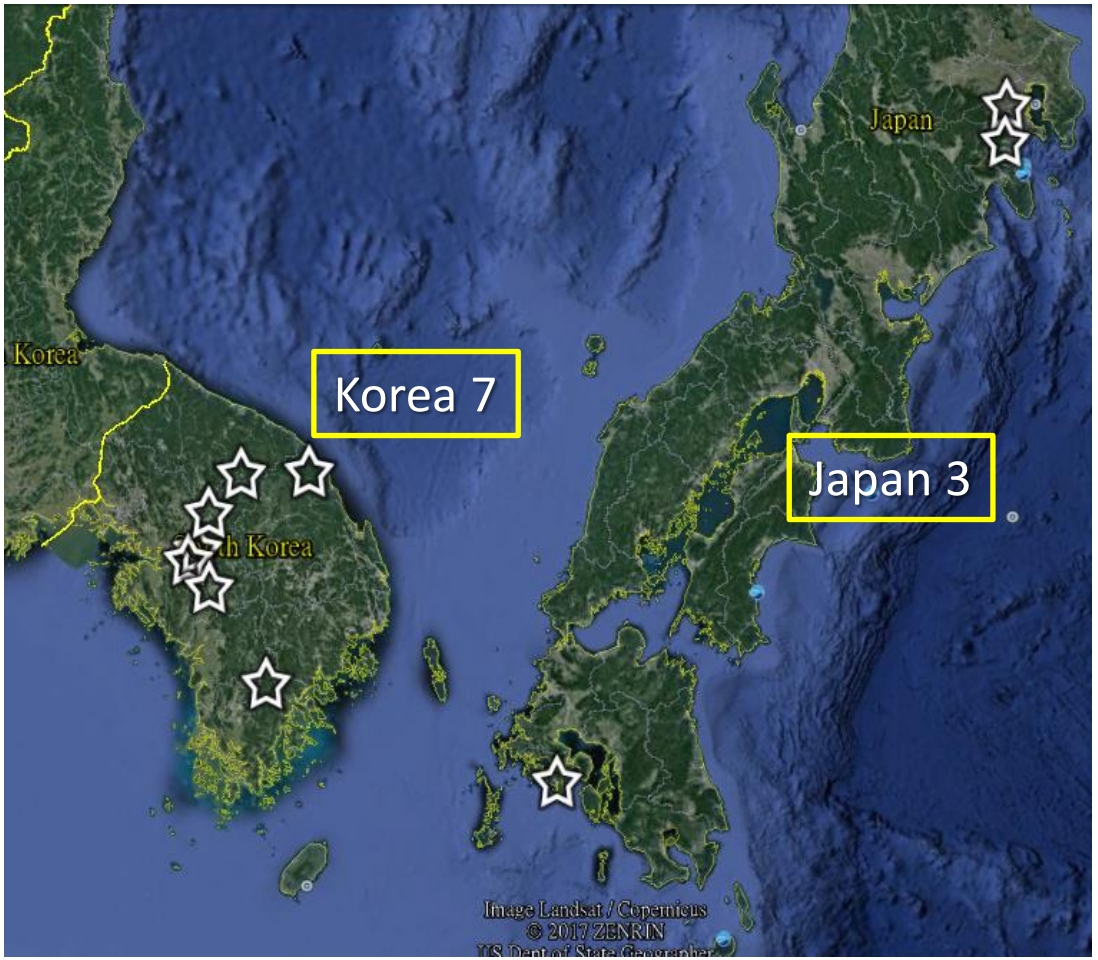
- GaN-MN currently (June 2017) has:
  - **23** stations operating in **9** countries/regions in **3** continents
  - Over **30** million individual measurements had been collected

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Current stations (23 in total):


Hong Kong 2
Macau 3


Taiwan 3


Japan
Korea
Korea 7
Japan 3
Image Landsat / Copernicus
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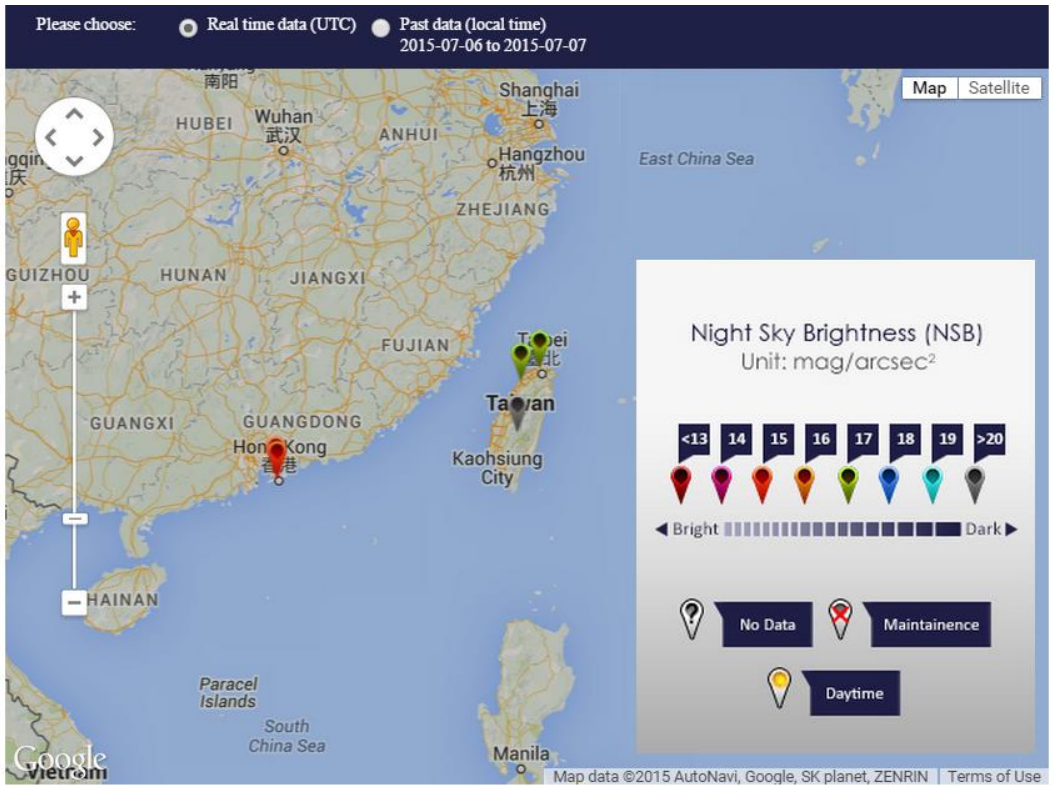
Data sharing:

1. Public interface of GaN-MN (embeded in Google map)

http://globeatnight-network.org/



- Location currently at night: instantaneous real-time data
- Location currently during day-time: median value of NSB taken during previous night

Data sharing:
2. Real-time database

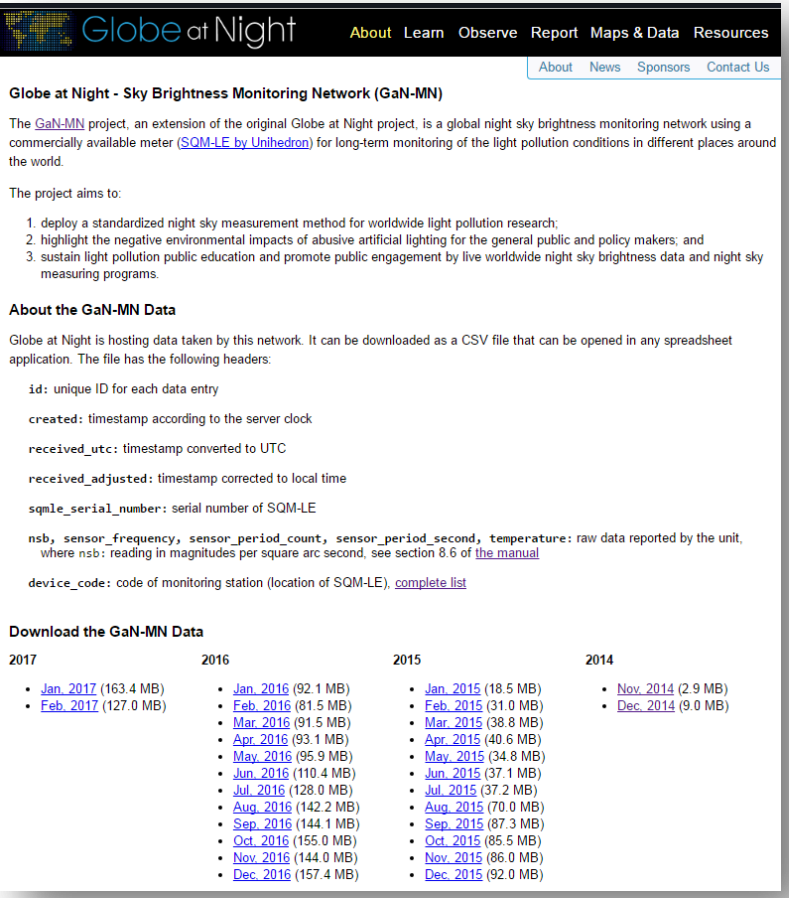
- All NSB data collected from GaN-MN stations fed to a MySQL database automatically and instantaneously
- Full sharing of real-time data from all stations among participating stations
- Participants access database through a user-friendly web-based interface
- Database allows for studies of temporal and geographical variations of light pollution and their correlations with various natural and artificial factors

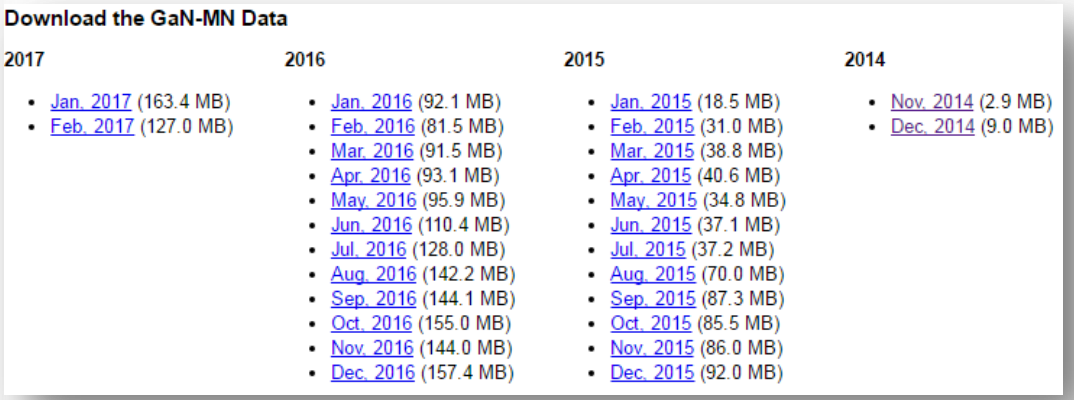
Data sharing:

3. Archival database (accessed through *Globe at Night* page)

https://www.globeatnight.org/gan-mn.php

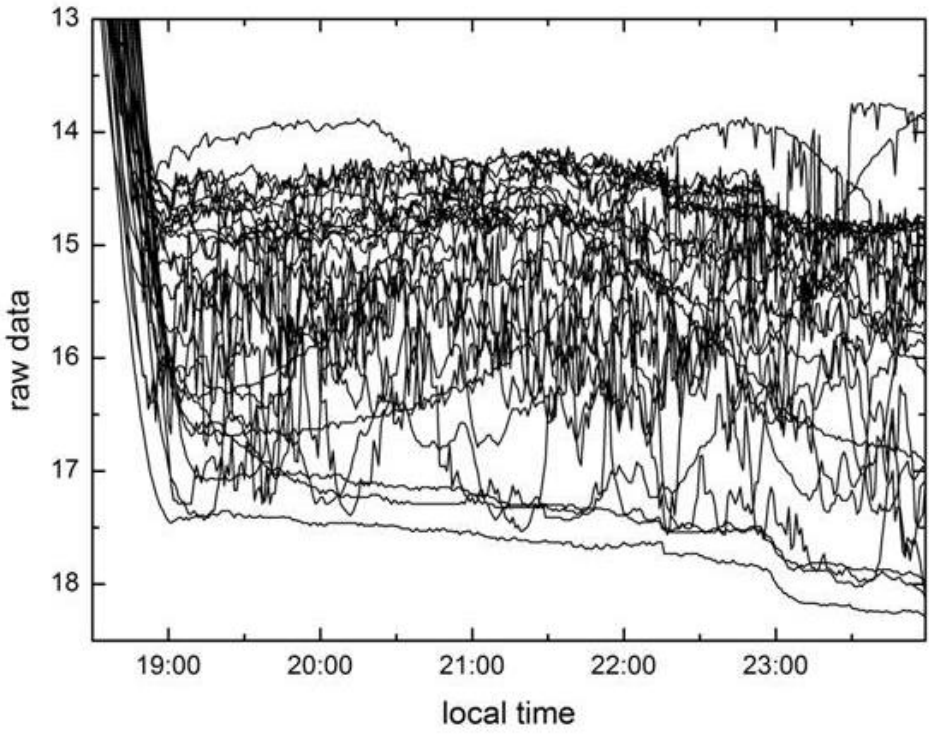
(Home page > Maps & Data)





- New archival file around once per month
- Raw data only limited quality check. Please contact us for details.

Raw data taken over one month at one station between 18:30 – 00:00



Astronomical

Galaxy, starlight, moonlight, sunlight, etc

Meteorological / Atmospheric

Cloud, rain, air pollution, etc

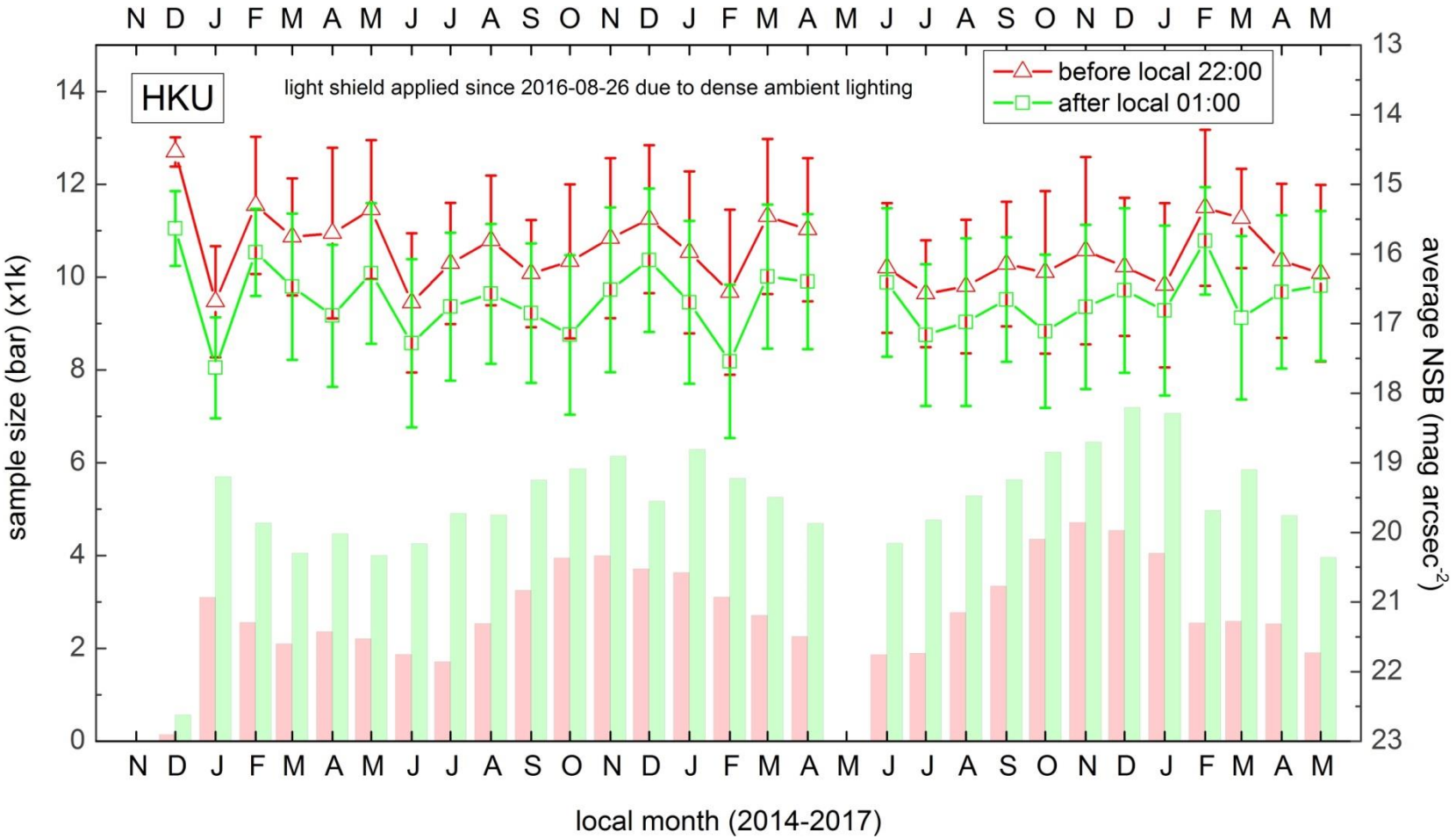
Anthropological

Public and private lighting, different colors, different angles, LED, etc

Data Selection

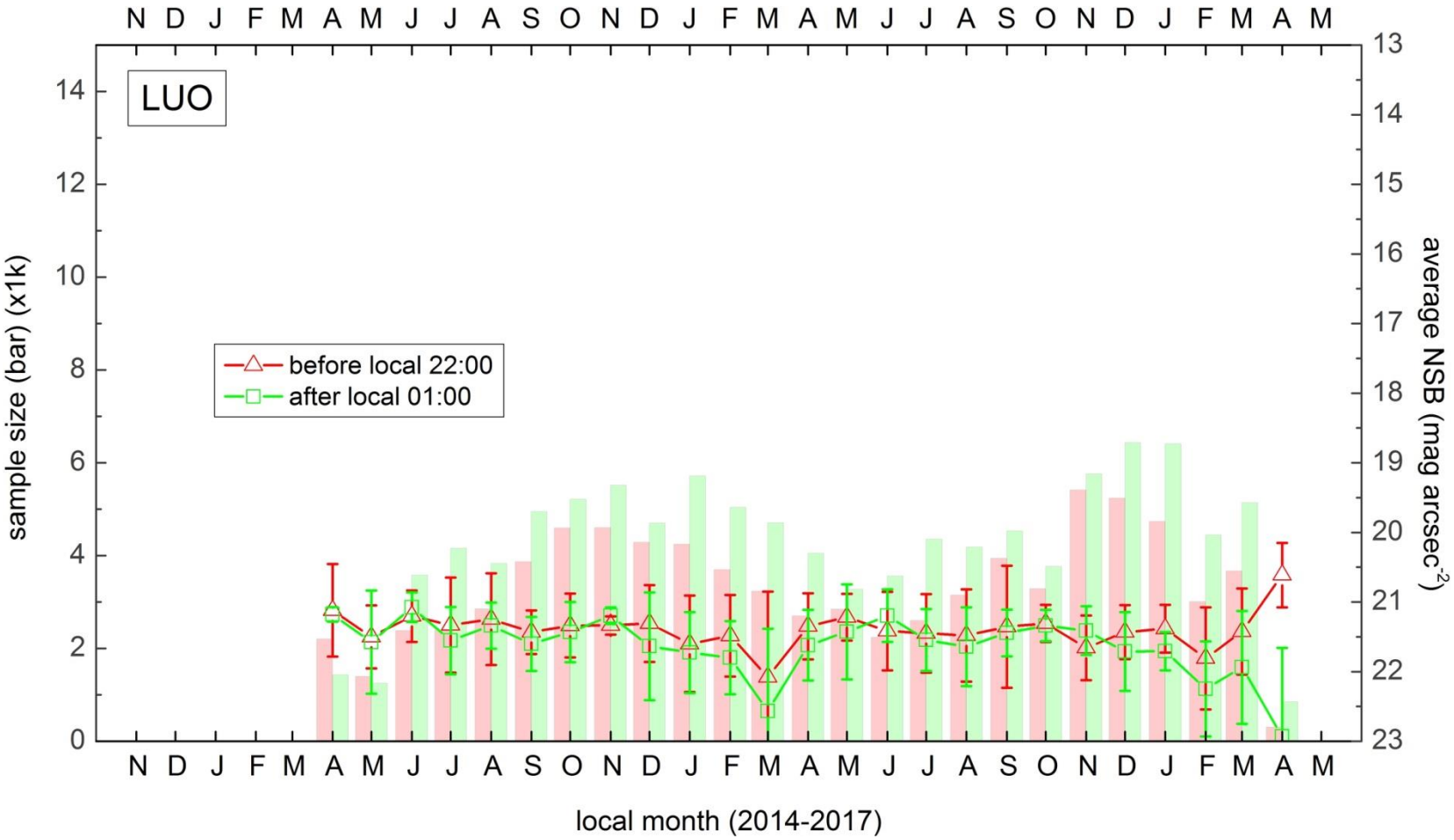
- For this particular analysis, focus on how and how much artificial lighting can affect the observed NSB (**urban skyglow**)
- Data excluded due to:
  - Sun (twilight)
  - Moon
  - artificial activities (such as observatory functions, etc)
- Data NOT excluded:
  - star/planetary light, Milky Way galaxy
  - rain
  - cloud

Monthly sample size (bars) and average NSB (lines) of a GaN-MN **urban** station (Hong Kong)



- ✓ Early evening brighter than late evening (lighting usage)
- ✓ Seasonal fluctuations (variations of cloud amount)

Monthly sample size (bars) and average NSB (lines) of a GaN-MN **rural** station (central mountain Taiwan)



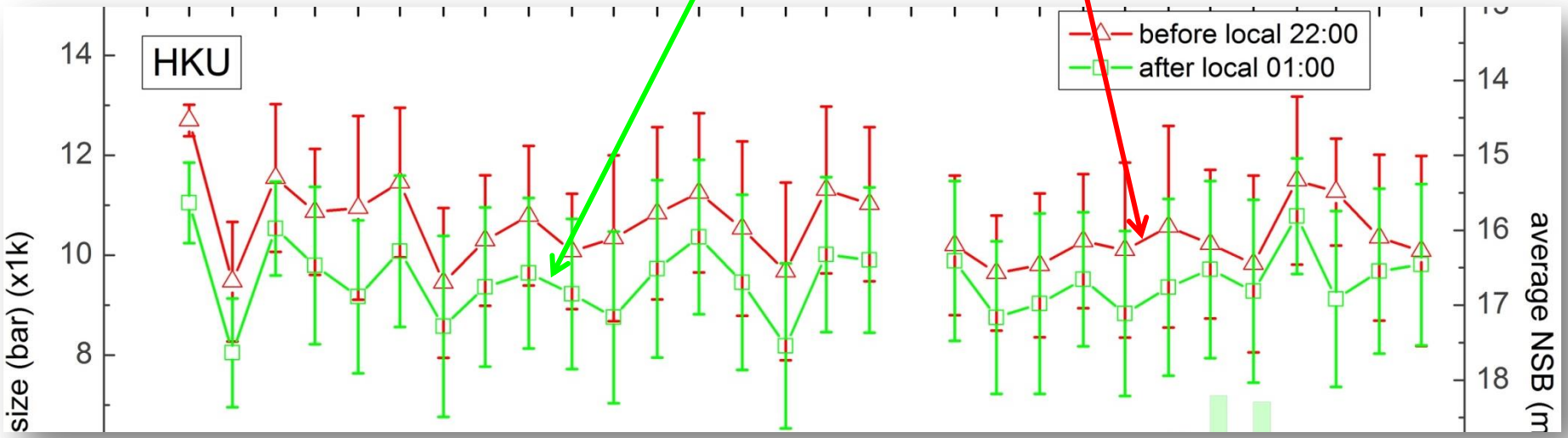
- ✓ Much darker NSB (land utilization and population density)
- ✓ Similar early and late NSB (minimal lighting usage)

Define parameter

$\Delta NSB_{late-early} = NSB_{late} - NSB_{early}$

Average NSB observed **after 01:00** local time = NSB_{late}

Average NSB observed **before 22:00** local time = NSB_{early}

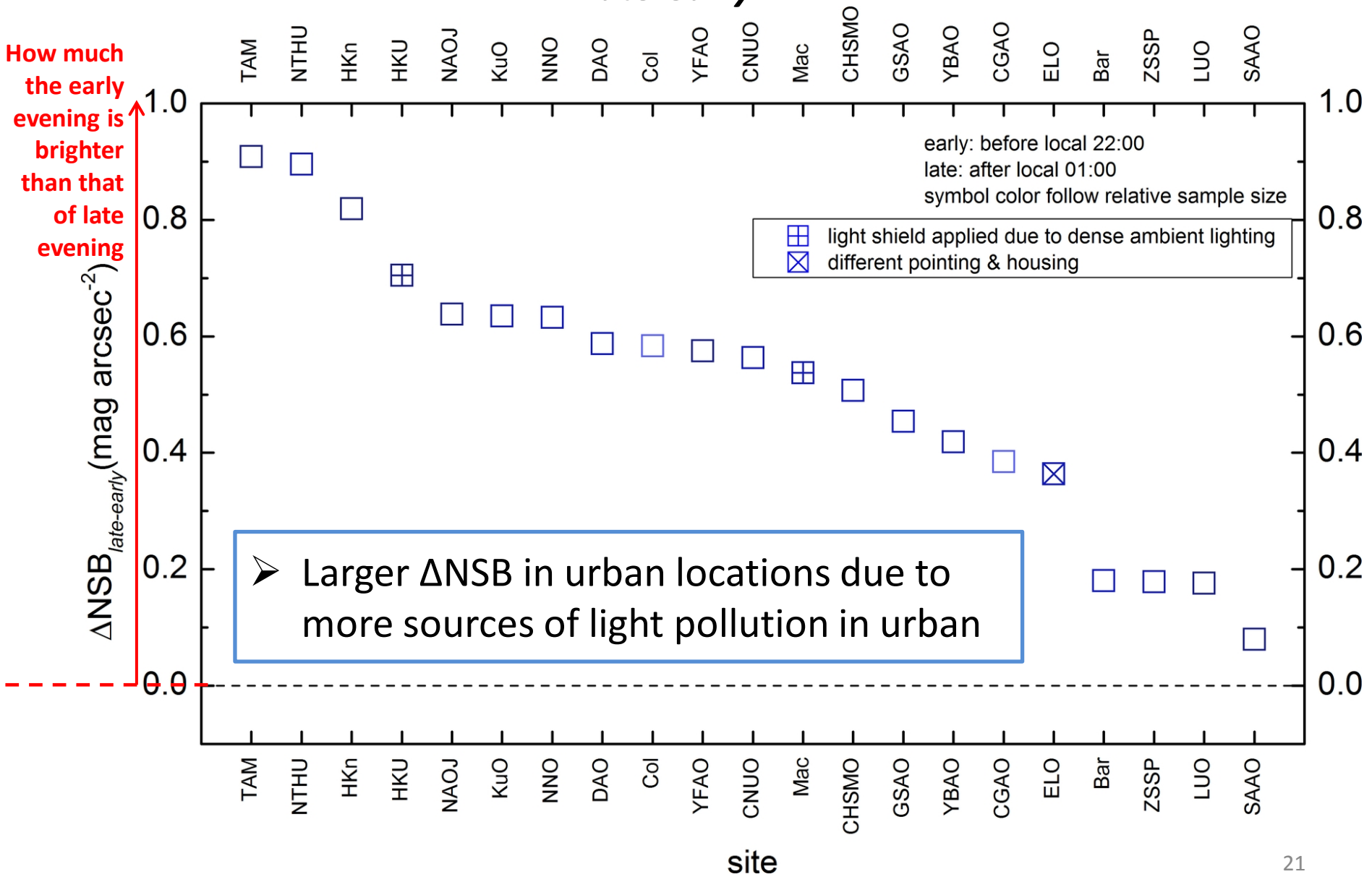


Positive $\Delta NSB_{late-early}$ ⇒ **darker** after mid-night

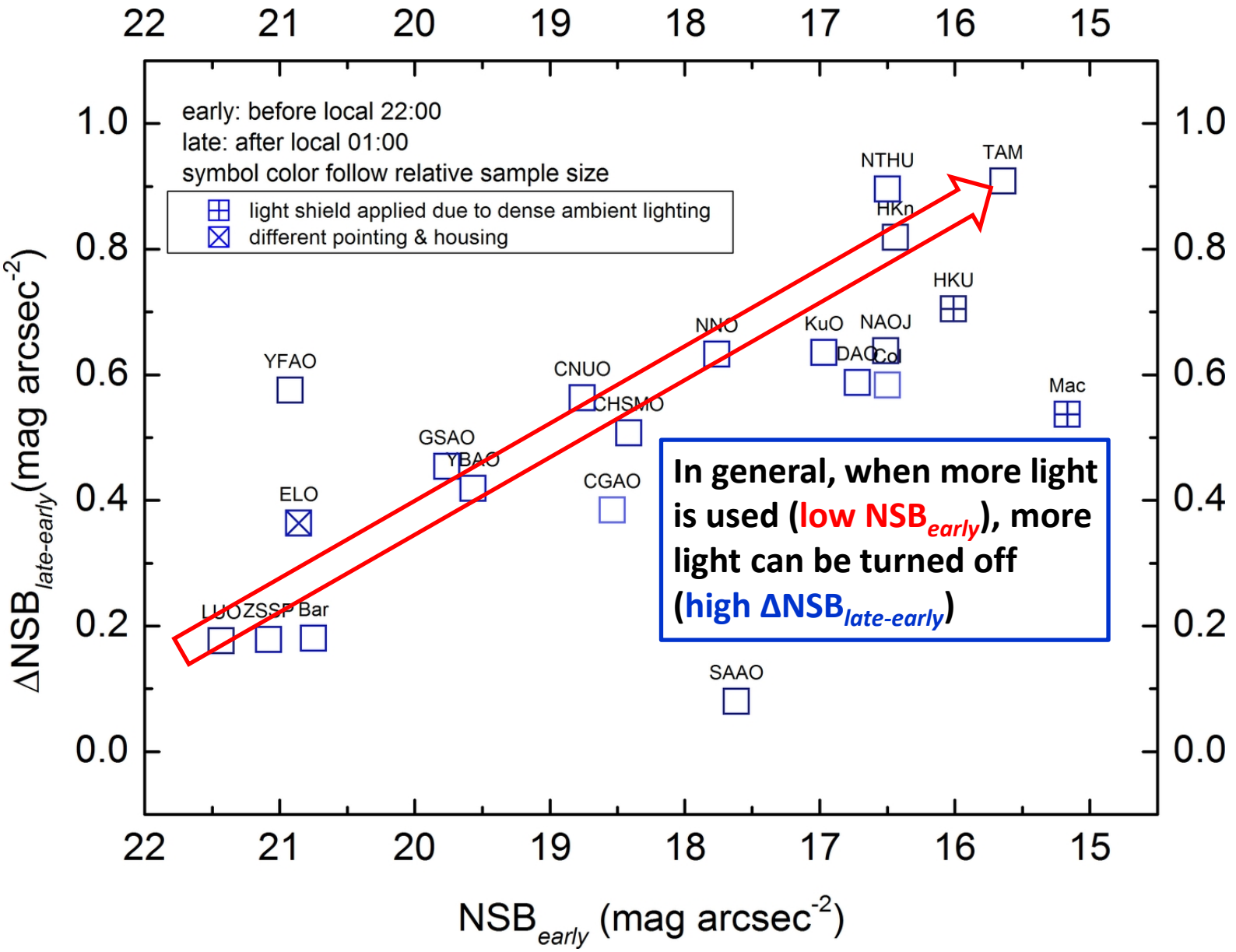
Negative $\Delta NSB_{late-early}$ ⇒ **brighter** after mid-night

Similar to "t-Grad" introduced by Thomas Posch

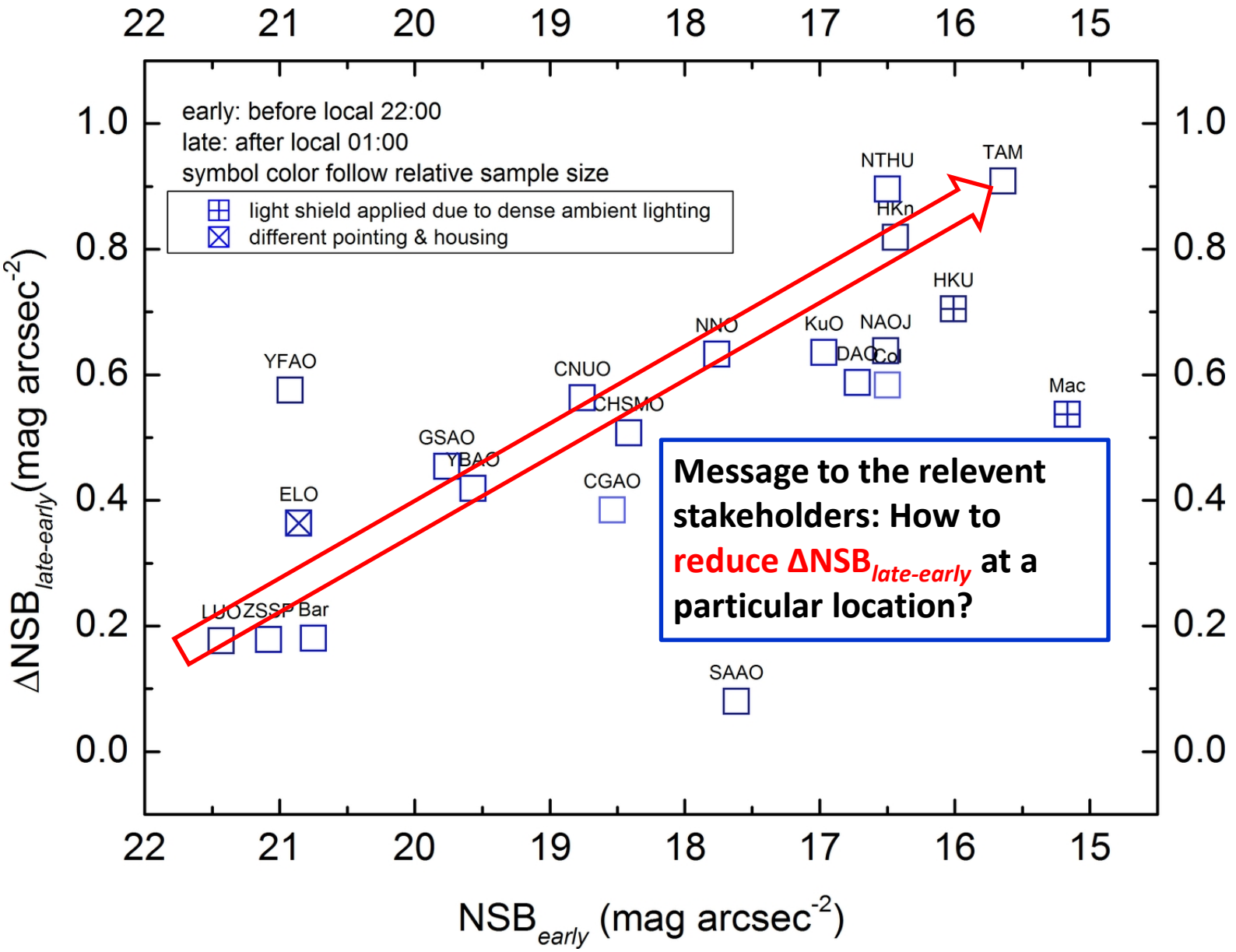
Average $\Delta NSB_{late-early}$ for each station



Average $\Delta NSB_{late-early}$ vs NSB_{early} for each GaN-MN station

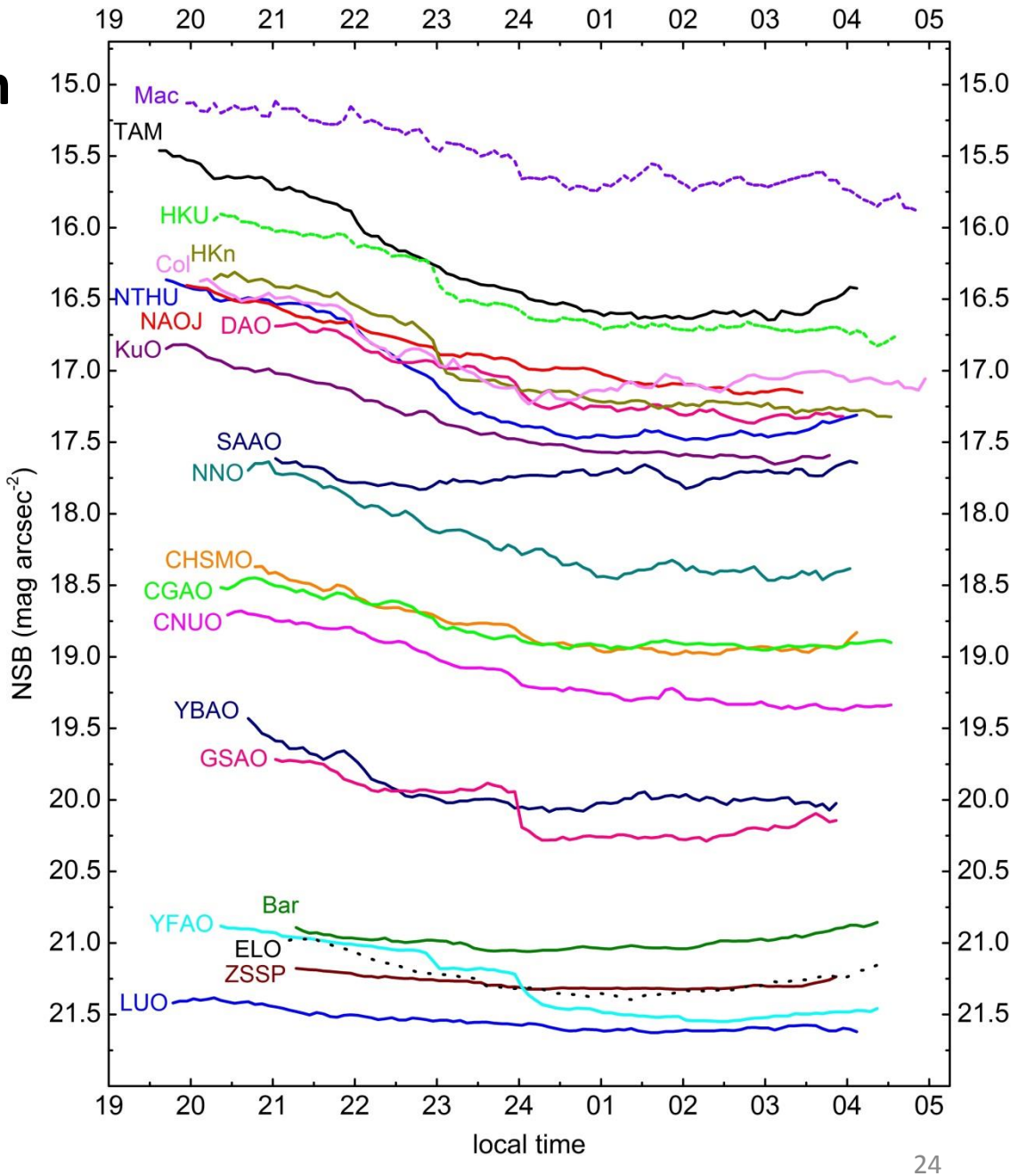


Average $\Delta NSB_{late-early}$ vs NSB_{early} for each GaN-MN station



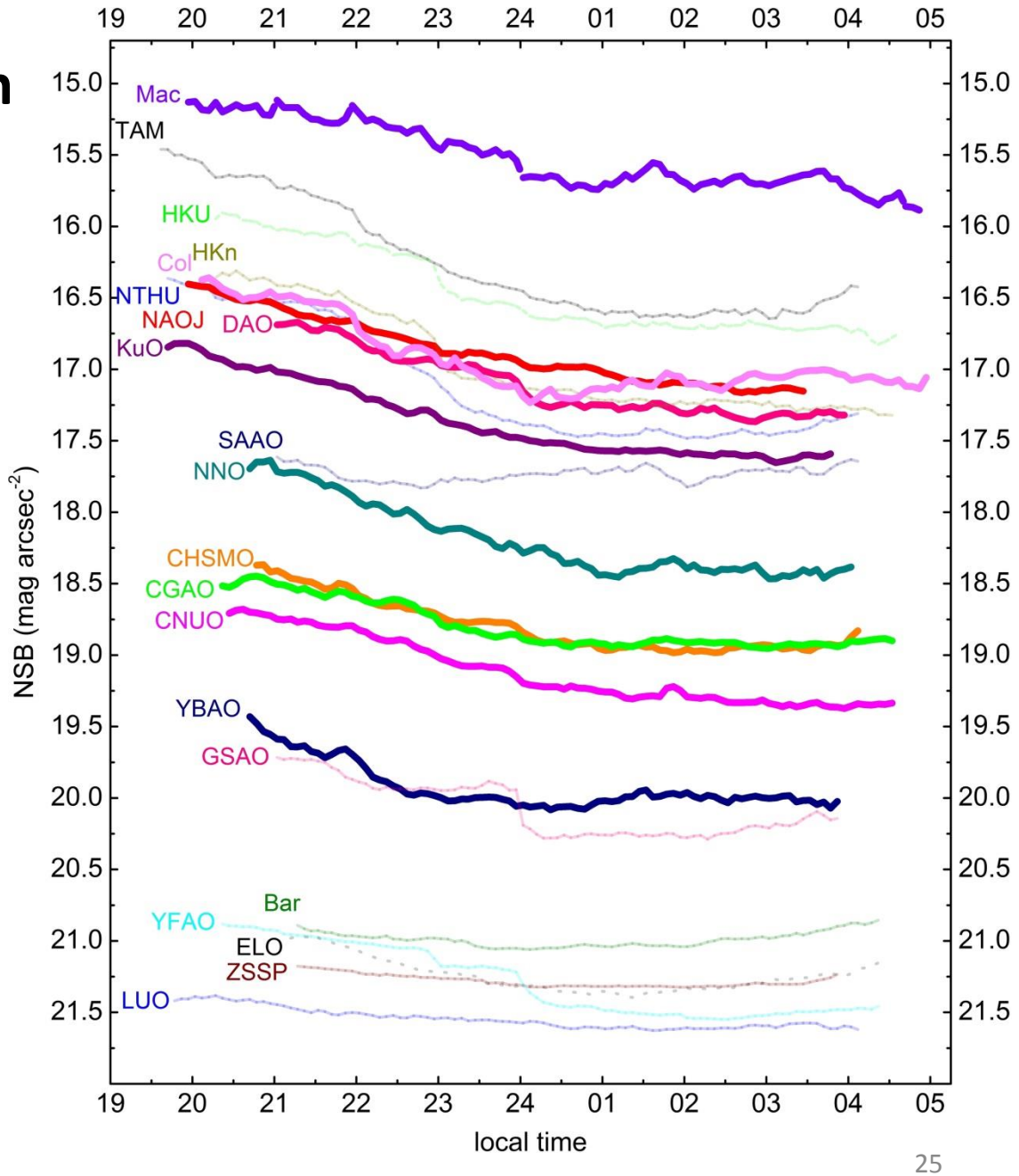
Average nightly variation of NSB for each station

- "Jellyfish scotograph" (introduced by Thomas Posch)
- Huge range of NSB among stations
- Different latitudes of stations lead to different sampling time (astro. dark durations)
- **Each curve is unique: Depicts the outdoor lighting usage at that particular location**



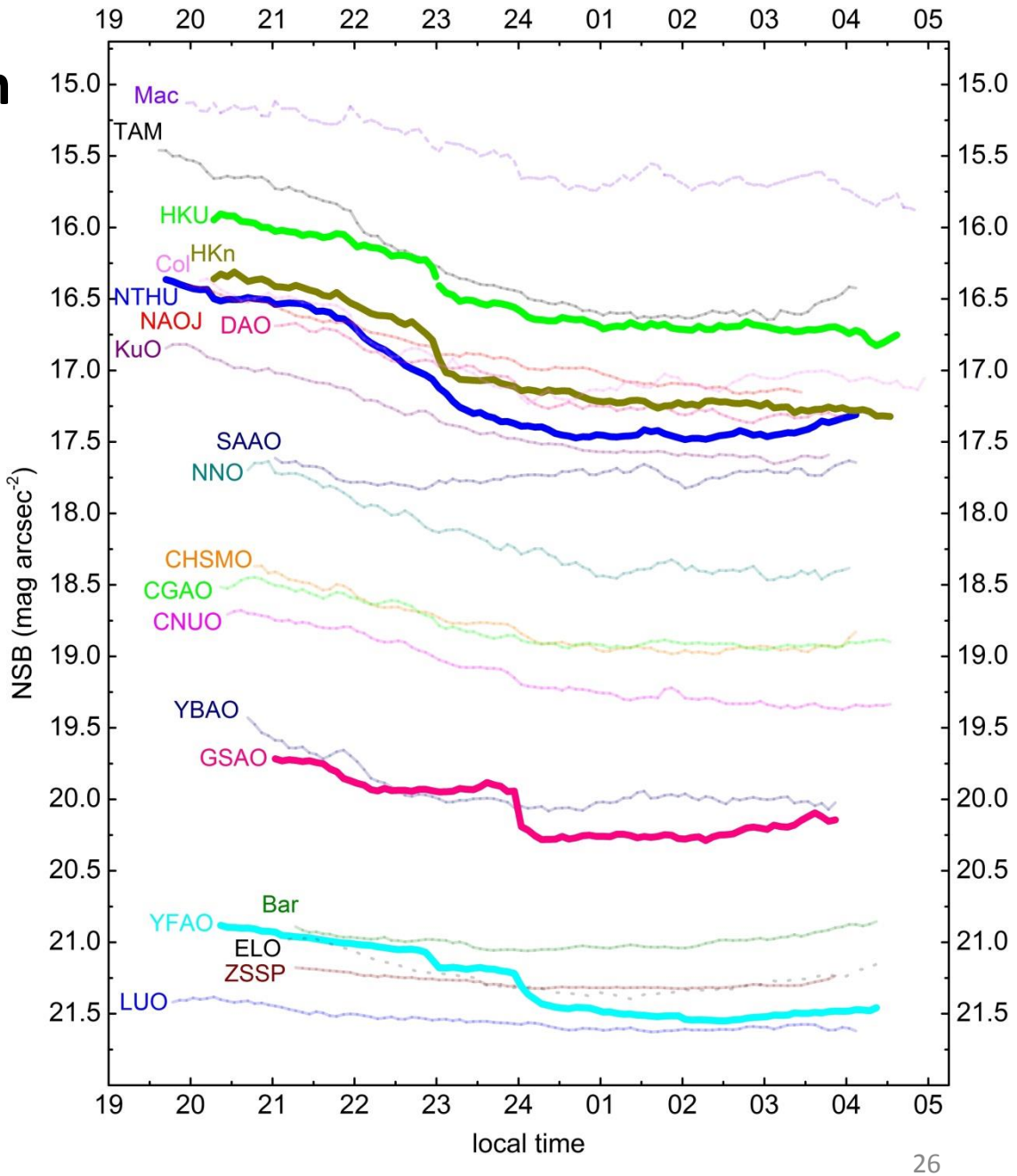
Average nightly variation of NSB for each station

- Most show a **gradual** decrease of sky brightness throughout the evening
- Suggest a decreasing amount of light pollution gradually due to reduction in light usage



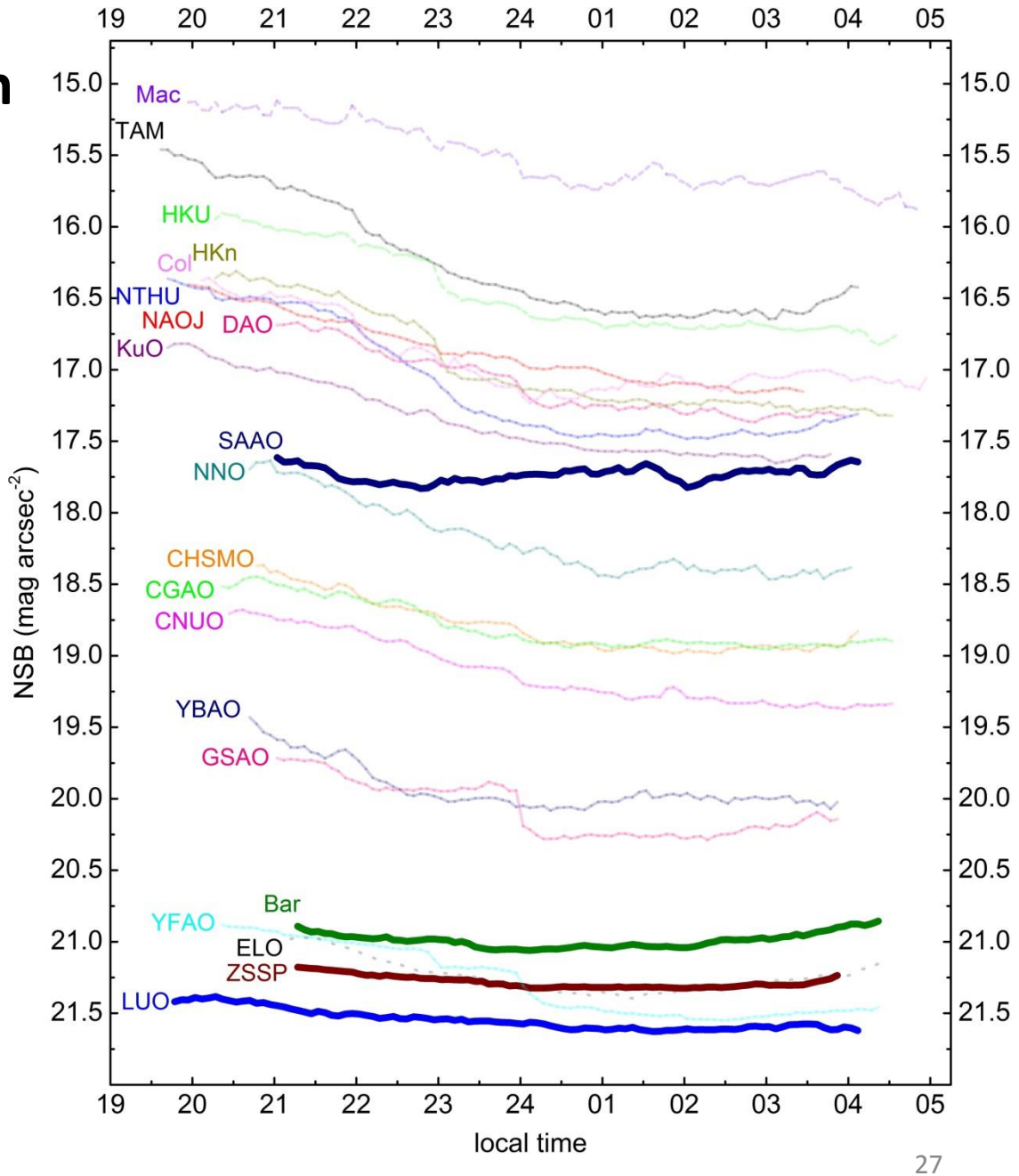
Average nightly variation of NSB for each station

- Some locations reveal one or multiple **sharp drops** (“curfews”) in sky brightness throughout the evening
- Lighting pattern identified: massive switch-off of lighting at specific times every night



Average nightly variation of NSB for each station

- Some locations have **roughly steady** level of sky brightness throughout the evening
- Two types identified:
  1. minimal ambient lighting
  2. special lighting usages



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Easy to join in the effort
- All you need are:
  - A working SQM-LE with the standard Housing from Unihedron
  - Power supply and internet connection
- Benefits:
  - Present your results real-time to the world
  - Let’s fight light pollution together!

Thank you!

For more information on the GaN-MN or willing to join,

1) Visit: http://globeatnight-network.org/
2) Email me (Chu Wing SO) at: globeatnight.network@gmail.com or gan-mn@qq.com